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Controller Area Network (CAN) Bus J1939 Data Acquisition Methods and Parameter Accuracy Assessment Using Nebraska Tractor Test Laboratory Data

by

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CAN bus is a serial communications protocol network with the ability to transfer data in speeds up to 1Mbit/s (Bosch, 1991). CAN 2.0B allows for the broadcast of prioritized messages between nodes or Electronic Control Units (ECUs) in a multi-master system (Bosch, 1991). This multi-master system allows for any ECU to broadcast a message as long as the bus is free. CAN bus uses a physical layer comprised of a shielded twisted pair, two wire system; CAN high (CAN_H) and CAN low (CAN_L) (Bell, 2002). CAN is a 5 V DC system where both CAN_H and CAN_L sit idle at 2.5 volts, and when a message is broadcast, CAN_H raises to 5 volts and CAN_L drops to 0 volts (Bell, 2002), producing a 5 volt differential to create a square wave of a certain size and timing location to indicate a message and the pertinent information within that message. An oscilloscope reading from a presentation during the 2013 Agricultural Equipment Technology Conference (Darr, 2013) shows a higher layer CAN message (Figure 1).

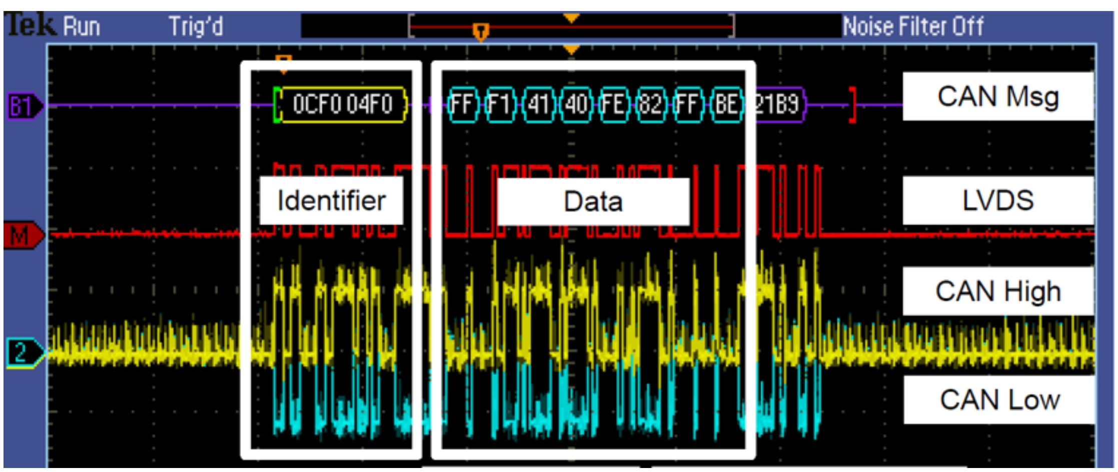

Figure 1: Oscilloscope Image courtesy of Iowa State University shows the 0x00F004 PGN Message with the data following after the identifier

SAE J1939

The Standards of Automotive Engineering began work on a higher layer CAN protocol draft in the early 1990's. This higher layer protocol is based on the seven layers of the Open Systems Interconnection (OSI) model (Figure 2) (Kvaser, 2014). SAE J1939

utilizes the CAN 2.0B framework to broadcast a 29 bit message identifier (Bell, 2002). SAE J1939 uses a pre-defined message format to allow for multiple manufactures to have similar systems (Voss, 2008). The SAE J1939 message is formed from Parameter Group Number (PGN). SAE J1939 was proposed for use in agricultural equipment in 1993 before the first draft of the document came out (Stone & Zachos, 1993).

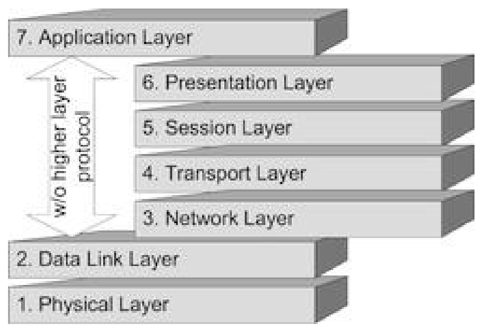

Figure 2: The OSI 7-Layer Reference Model showing higher layer protocol which is implemented in the SAE J1939 standard

SAE J1939 messages are broadcast in hexadecimal format with certain bit timing and byte sizing to indicate the priority of the message, the message identifier, as well as the data within that message. An example of one line of hexadecimal data from PGN F004 (Electronic Engine Controller 1) (Source: SAE J1939 Document) as recorded from a Vector CAN Logging hardware/software package (CANcaseXL, Vector, Novi, MI/ CANalyzer, Vector, Novi, MI) in American Standard Code for Information Interchange (ASCII) shows as:

```
0.012522 1   CF00400x     Rx     d 8 F0 FF 93 8C 1A FF FF FF
```

Figure 1 illustrated the same message (PGN F004) as it is seen by an oscilloscope being broadcast across the bus. The message identifier (F004) is at the beginning of the message to indicate to the other ECU's on the bus where the message is coming from and the data contained within that message (e.g., F004 contains Actual Percent Engine Torque and Engine Speed messages). A Suspect Parameter Number (SPN) is assigned to

Figure 3: 700 Horsepower Dry Gap Eddy Current Dynamometer used by the Nebraska Tractor Test Laboratory

Controller Area Network Interface

For this study, the interface with the tractor's CAN bus was achieved through the Deutsch HD10-9-1939 J1939 diagnostic connector (Figure 4). The J1939 diagnostic connector is a universal solution for Heavy Trucks and Off-Road equipment including agricultural equipment.

Figure 4: Deutsch HD10-9-1939 J1939 Diagnostic Connector: Green= CAN Low, Yellow= CAN High, Red= Voltage source, Black= Vehicle Ground